Machinery Messages

Case History

The case of the rotating unbalance

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Our Machinery Diagnostic Services group (MDS) was asked to balance an Induced Draft (ID) fan located on the sixth floor of a power house at a grain distillery. The power house is approximately 60 to 70 years old and the support structure is quite flexible. The plant has three ID fans, all operating at the same speed and within close proximity of each other. Two of the three are located next to each other on the fifth floor directly below the fan we were concerned with. All three fans were resized and replaced two years previously when the plant's boiler was upgraded. Since the time of the replacement, the fan which we were asked to balance, ID Fan #1, had been balanced 24 times, or about once per month.

A 400 HP induction motor, connected to the fan by a flexible coupling, drives the fan at 885 rpm. The fan and motor rotors are supported on sleeve type bearings. Proximity probes were used for two reasons. First, due to the nature of sleeve bearings, velocity probes would not allow us to balance the fan to the same levels of accuracy as proximity probes. This is because typically there is a greater than 3:1 ratio of shaft relative to casing motion. Second, velocity probes would be more susceptible to motion created by the other two fans. Therefore, amplitude and phase errors might result. The previous balance attempts had all been made with hand-held velocity transducers. See Figure 1 for probe orientations and machine configuration.

We requested that the fan be sandblasted clean before any balance attempts were made, which is standard procedure. Machinery data was collected using an ADRE®3 System. Initial 1X values, compensated for runout, for the #1 ID fan were 330 μm (13.0 mils) peak-to-peak at 259° on the inboard bearing in the horizontal direction and 376 μm (14.8 mils) peak-to-peak at 282° on the outboard bearing, again in the horizontal direction. Experience suggested, and polar plots confirmed, that the fan was operating below its first balance resonance. Therefore, in our initial correction attempt, we installed 340 g (12 ounces) at 75° **A**gainst **ROT**ation (AROT) or approximately 180° opposite from the phase of the vibration. Not only did the results not meet expectations (Figure 2), but they indicated an increase in vibration to 686 μm (27.0 mils) peak-to-peak at 213° and 706 μm (27.8 mils) peak-to-peak at 229°, respectively.

The vectors, though, appeared to move together; the weights just needed to be rotated and reduced. Using the available data, we calculated and installed 238 g (8.4 ounces) at 332° AROT. The fan was restarted and vibration levels reached 325 μm (12.8 mils) peak-to-peak at 247° and 353 μm (13.9 mils) peak-to-peak at 268°. Neither the vector's length nor its phase shift were even close to the values we would have predicted based on the calibration weight (Figure 3). Drawing on a past experience with an induced draft fan at a coal mine, and knowing the past history of this fan, we raised the question, "Can any dust or dirt be getting trapped in the interior of the fan's hub?"

We planned a simple test to determine if dirt were the cause. The test involved starting the fan from a position 180° from the last starting point. Remember, we knew where this starting

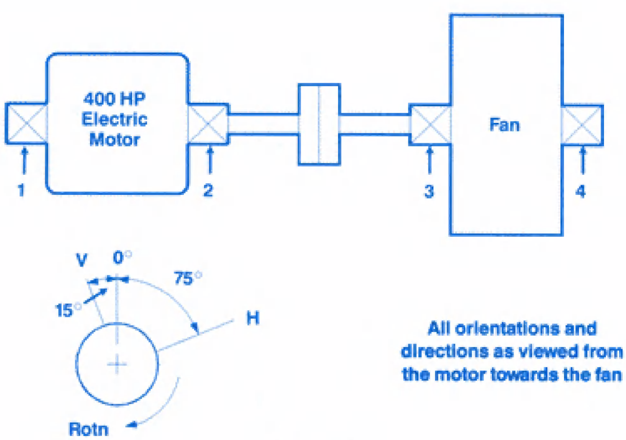

Figure 1
Machinery arrangement sketch

point was due to installation of a trial weight. If the amplitude and phase were repeatable during this run, then dirt in the rotor hub was probably not a problem. If, however, there were a significant change, this would indicate that something was affecting the balance state of the fan. Our question was answered before we ran the test when, as the fan coasted down to 10 rpm, we removed the access plate and saw a cloud of dust appear every time the fan passed a certain point.

Further investigation revealed that an open area surrounding the anchor bolts let dust into the hub of the fan. Every time the fan was started up, the dirt would accumulate in a different position in the hub, creating a variable unbalance. To solve the problem, two holes were cut at the outer diameter of the hub and the contaminating dirt was blown out with compressed air. All of the holes were then sealed. After a couple of balance runs, the vibration was reduced to less than 38 μm (1.5 mils) peak-to-peak at 1X. Table 1 indicates the final amplitudes, influence vectors and balance weights of Fan #1.

The #2 ID Fan was next on our list; its initial, compensated 1X values were 500 μm (19.7 mils) peak-to-peak at both inboard and outboard horizontal locations. After cleaning its hub and sealing all dust ingress holes, balancing brought this fan's vibration below 41 μm (1.6 mils) peak-to-peak. Table 2 indicates the final amplitudes, influence vectors and balance weights of Fan #2.

It is important to track influence vectors for your machinery as this information enables you to make good balance moves, which should result in "one shot" balancing. Influence vectors are also useful in shaft crack and malfunction analysis. If the influence vectors change radically, it typically indicates a change in system stiffness. It should be noted, however, that influence vectors will change with speed and load conditions.

The #3 ID Fan's hub was also cleaned and sealed, and vibration levels dropped to an acceptable level. All the fans have been running for over a year without any interruption in service or any sign that balancing is necessary. ■

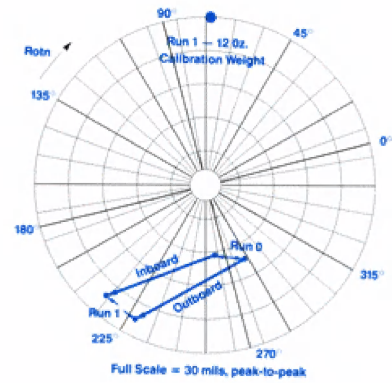

Figure 2
Calibration weight balance data

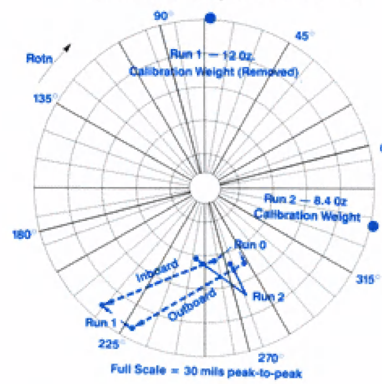

Figure 3
Balance data after second weight addition

Fan #1 - Summary Table

Probe Location	Initial 1X Amplitude	Initial Phase	Final 1X Amplitude	Final Phase	Weight *	Influence Vector [mils/oz]	Influence Phase
3XD	22.0 mils	229°	1.39 mil	169°	38 oz.	0.56	46°
3YD	18.4 mils	167°	0.64 mil	99°	at	0.48	343°
4XD	22.4 mils	248°	0.79 mil	114°	6°	0.60	63°
4YD	12.2 mils	137°	0.54 mil	352°		0.33	312°

Table 1

Fan #2 - Summary Table

Probe Location	Initial 1X Amplitude	Initial Phase	Final 1X Amplitude	Final Phase	Weight *	Influence Vector [mils/oz]	Influence Phase
3XD	25.8 mils	234°	1.27 mils	301°	78 oz.	0.32	350°
3YD	24.5 mils	351°	1.14 mils	67°	at	0.31	107°
4XD	22.9 mils	245°	1.52 mils	290°	61°	0.28	1°

Table 2

Note: *Fan #1 is a different size and had a different support structure than Fan #2. Therefore, the weights used for balancing the two fans were completely different.*

** It would be more accurate to say that mass is added to the rotor to balance it, however, we have decided to stay with the more common usage, "weight."*